Using the Gini coefficient to Determine Consolidation in the British Columbia Shellfish Aquaculture Industry

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ABSTRACT

This report used the Gini coefficient to measure consolidation in the shellfish aquaculture industry in British Columbia. The Gini coefficient is a ratio that measures the divergence between an idealized cumulative frequency distribution curve and a realized cumulative frequency distribution curve. The Gini coefficient takes a value between 0 and 1 where 0 indicates a highly equal distribution and 1 indicates a highly unequal distribution. Shellfish farm gate values for the years 2000 to 2008 inclusive and for the years 2011 to 2014 inclusive were obtained from the Annual Aquaculture Statistical Reports. Complete data sets for the reporting years 2009 and 2010 were not available and these years were therefore excluded from the study. The data for each year were ranked from the smallest farm gate value to the largest value and a relative cumulative frequency distribution for each year was constructed. Gini coefficients were then calculated for each year included in the study. The Gini coefficients followed a rising trend line indicating increasing consolidation in the British Columbia shellfish aquaculture industry.

RÉSUMÉ

Ce rapport a utilisé le coefficient de Gini pour mesurer la consolidation dans l'industrie de la conchyliculture en Colombie-Britannique. Ce coefficient est un rapport qui mesure l'écart entre une courbe de distribution de fréquence cumulative idéalisée et une courbe de distribution de fréquence cumulative réalisée. Le coefficient de Gini prend une valeur entre 0 et 1, où 0 indique une répartition très égale et 1 indique une répartition très inégale. Valeurs de la ferme crustacés pour les années 2000 à 2008 inclusivement et pour les exercices 2011 à 2014 inclusivement ont été obtenues à partir des rapports annuels de l'aquaculture statistique. Ensembles de données complètes pour les années de référence 2009 et 2010 n'étaient pas disponibles et ces années ont donc été exclus de l'étude. Les données pour chaque année ont été classées de la plus petite valeur à la ferme de la plus grande valeur et une distribution de fréquence cumulée relative de chaque année a été construite. Coefficients de Gini ont ensuite été calculés pour chaque année inclus dans l'étude. Les coefficients de Gini ont suivi une ligne de tendance haussière indiquant consolidation croissante dans l'industrie conchylicole Colombie-Britannique.

INTRODUCTION

The Gini coefficient was developed by Carrodo Gini (1884-1965) as a measure of dispersion contained in frequency distributions and is most often applied to determine income inequality within a nation. Gini reasoned that if the total income of a nation was equally distributed then 10% of the population would own 10% of the total income, 50% of the population would own 50% of the total income and so on until at last 100% of the population would own 100% of the total income. Displayed graphically, this relationship would result in a straight line making a 45 degree angle from each axis similar to the black line shown in figure 1.

In reality, the distribution of income within most nations is rarely equal but rather tends to follow a distribution similar to the red line shown in figure1 and is often referred to as a Lorenz curve. The Gini coefficient is a ratio that measures the divergence between the idealized income distribution line and the Lorenz curve. It is calculated by dividing the size of area A shown in figure 2 by the total area under the line of equality or the sum of area A and area B. The Gini coefficient takes a value between 0 and 1with 0 indicating extreme equality and 1 indicating extreme inequality.

The Gini coefficient is the accepted standard method of measuring income distribution but it has other applications as well. As a measure of dispersion, the Gini coefficient has proved useful as a measure of consolidation within an industry. Abayomi and Yandle (2012) used the Gini coefficient to measure consolidation in the New Zealand fishing industry as a result of the introduction of individual transferable quotas (ITQ). The authors concluded that individual transfer quotas had increased inequality of catching rights by concentrating ITQs among a small group of fishers rather than the intended purpose of distributing the catch among many fishers with smaller capacity. A similar study was conducted by Agar et al (2014) to examine the introduction of individual fishing quotas (IFQ) into the Gulf of Mexico Red Snapper fishery. The Gini coefficient was used to measure the distribution of IFQs among fishers and discovered that the initial distribution of shares was highly unequal and did not change substantially during the first five years of the program. Baccante (1995) used the Gini coefficient to measure the frequency distribution of catch among Walleye anglers. The author concluded that most fish are caught by only a few anglers and that angler skill and equipment play an important role in shaping the catch distribution. Seekel (2011) on the other hand, compared Gini coefficients from angler catch distributions with Gini coefficients from probability distributions of expected catch size and concluded that angler success is not significantly different from a random catch model.

The Gini coefficient can be a useful tool for managers and policy makers or those otherwise responsible for the regulation of industry. They are simple to calculate and

provide a useful quantitative measurement for analyzing the structure of an industry and prove particularly helpful in understanding socio-economic and governance issues.

METHODOLOGY

The Gini coefficient is a dimensionless measure of statistical dispersion between an idealized income distribution as indicated by the black line in figure 1 and a measured income distribution as indicated by the red line. The extent of dispersion may be illustrated by area A on the graph. More specifically, the Gini coefficient can be mathematically calculated as the ratio of area A to the entire area under the idealized distribution line as expressed by:

$$G = \frac{A}{A + B} \tag{1}$$

It is obvious that the sum of area A and area B is equal to the area contained under the idealized income distribution line. If decimals are used to represent percentages as shown in figure 2 then both horizontal and vertical axes will range between 0 and 1. The area under the idealized income distribution line will be:

$$Area\ A + Area\ B = \frac{1}{2}\ b \times h = \frac{1}{2}\ 1 \times 1 = .5 \tag{2}$$

The Lorenz curve which forms the upper boundary of Area B is constructed by first ordering the farm gate values from the smallest amount to the greatest amount for each reporting year in the study. The relative cumulative frequency is determined by:

$$F_{c_m} = \sum_{i=1}^{i=m} \frac{y_i}{Y_t} \tag{3}$$

where y_i is the farm gate value reported by each shellfish site and Y_t is the total sum of all farm gate values reported in a given year.

The Lorenz curve is in fact not a curve but rather a series of straight lines connecting discrete data points. The size of Area B can therefore be calculated by fitting a series of rectangles below the curve and summing their areas as shown in figure 3. The height

of each rectangle can be calculated by taking the average between two sequential data points given by:

$$\overline{F_c} = \frac{F_{c_1} + F_{c_2}}{2} \tag{4}$$

The width of each rectangle is simply the reciprocal of the total number of data points. For example, if there were 100 data points in the sample then the distance between each sequential data point would be 1/100 and each rectangle would be 1/100 in width. The size of Area B can be determined by summing the areas of the rectangles under the curve according to the equation:

$$Area\ B = \sum_{i=1}^{i=n} \frac{F_{c_i} + F_{c_{i+1}}}{2n} \tag{5}$$

By substituting equation 5 into equation 2 and re-arranging, the size of Area A may be determined by:

$$Area\ A = \frac{1}{2} - \sum_{i=1}^{i=n} \frac{F_{c_i} + F_{c_{i+1}}}{2n} \tag{6}$$

By substituting equation 5 and equation 6 into equation 1 and rearranging, the Gini coefficient may be calculated as:

$$G = \left(\frac{1}{2} - \sum_{i=1}^{i=n} \frac{F_{c_i} + F_{c_{i+1}}}{2n} \right) \div \frac{1}{2} \tag{7}$$

$$G = \left(\frac{1}{2} - \sum_{i=1}^{i=n} \frac{F_{c_i} + F_{c_{i+1}}}{2n} \right) \times 2 \tag{8}$$

$$G = 1 - \sum_{i=1}^{i=n} \frac{F_{c_i} + F_{c_{i+1}}}{n} \tag{9}$$

ANALYSIS

Shellfish farm gate values for the years 2000 to 2008 inclusive and for the years 2011 to 2014 inclusive were obtained from the Annual Aquaculture Statistical Reports. Complete data sets for the reporting years 2009 and 2010 were not available and these years were therefore excluded from the study. Furthermore, not all shellfish licenced within a given year will report farm gate sales due to closures, maintenance and sites that are left fallow. The data for each year were ranked from the smallest farm gate value to the largest value and the relative cumulative frequency as given by equation 3 was determined. The Gini coefficient was then calculated according to equation 9 for each year included in the study.

The Gini coefficient and descriptive statistics for each reporting year appears in Table 1. The symbol Y_{tot} represents the total income reported from farm gate values for all shellfish producers and the symbol n represents the number of shellfish producers reporting non-zero income from farm gate sales. The cumulative frequency distributions of reported income for each year reveal a trend towards increasing convexity and greater divergence from the ideal distribution line. Cumulative income distribution curves for selected years are shown in figure 4. The Gini coefficients calculated over the period in study follow a rising trend as shown in figure 5 and increase an average of 0.01 per year.

CONCLUSION

There are several methods for determining an industry's market concentration but the Gini coefficient provides a metric that easy to understand and simple to calculate. In this study, the Gini coefficients calculated for the years 2000 to 2008 and 2010 to 2014 inclusive based on farm gate income received by shellfish aquaculture producers in British Columbia were found to follow a rising trend and increased an average of .01 per year. Since the Gini coefficient ranges between 0 and 1 with 0 representing a highly equal distribution and 1 representing a highly unequal distribution, a rising trend points to increasing concentration of income. It is therefore concluded that production in the British Columbia aquaculture industry is consolidating among the large producers.

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APPENDIX

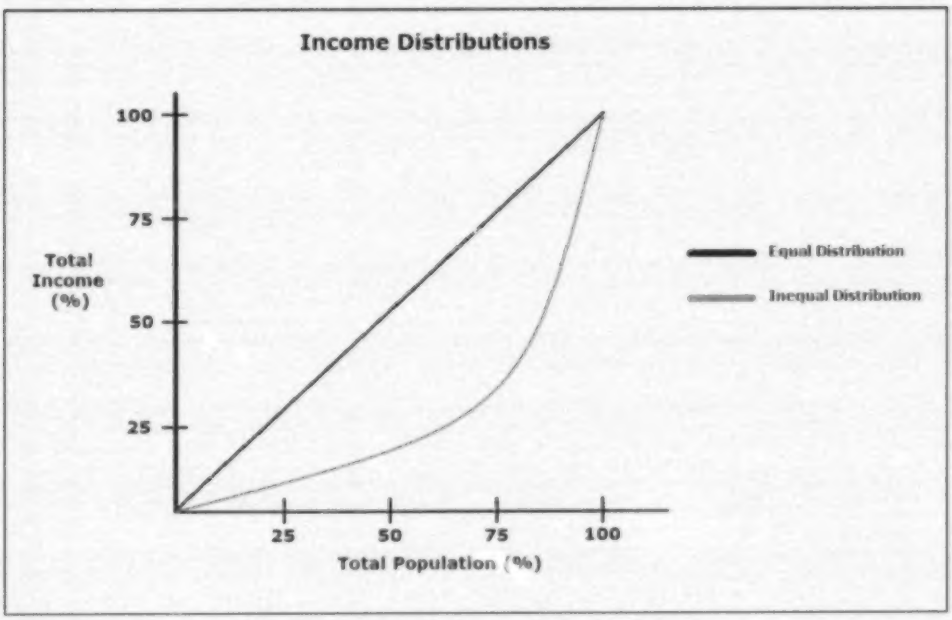
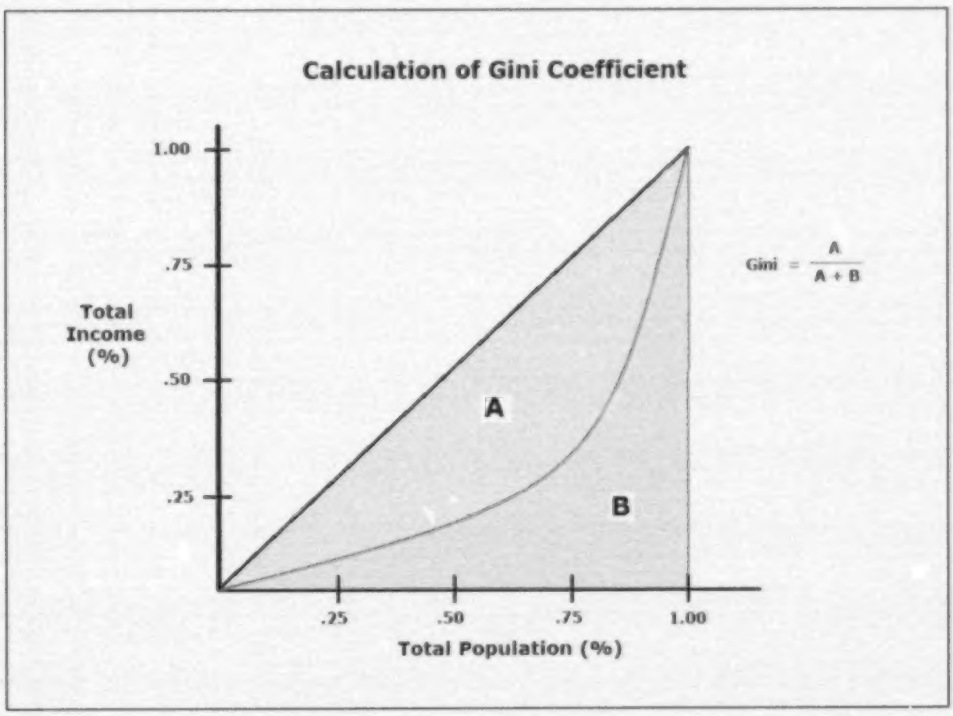


Figure 1



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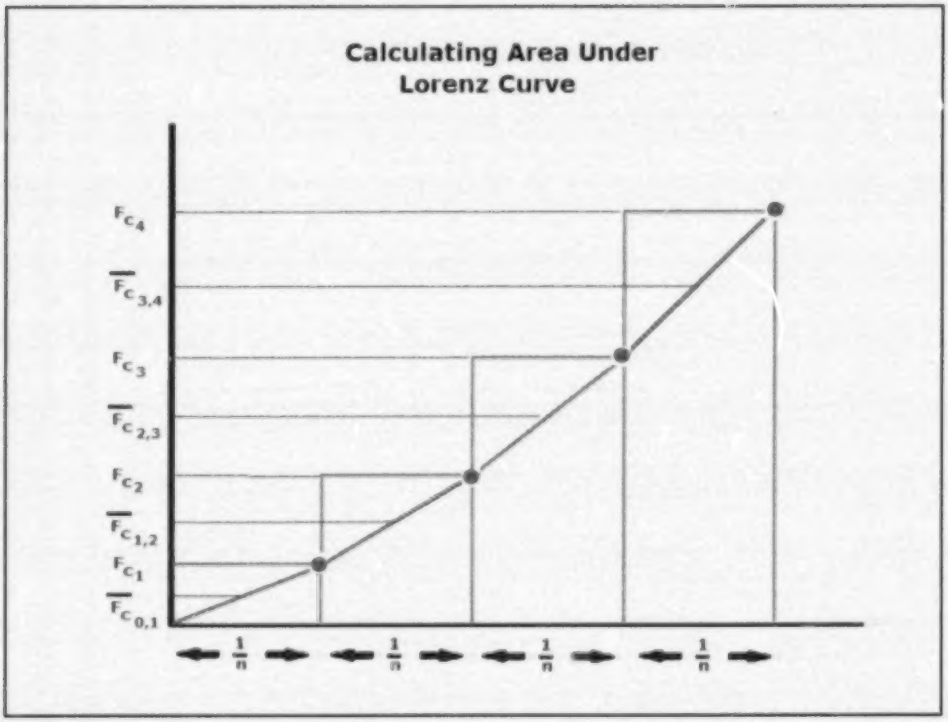

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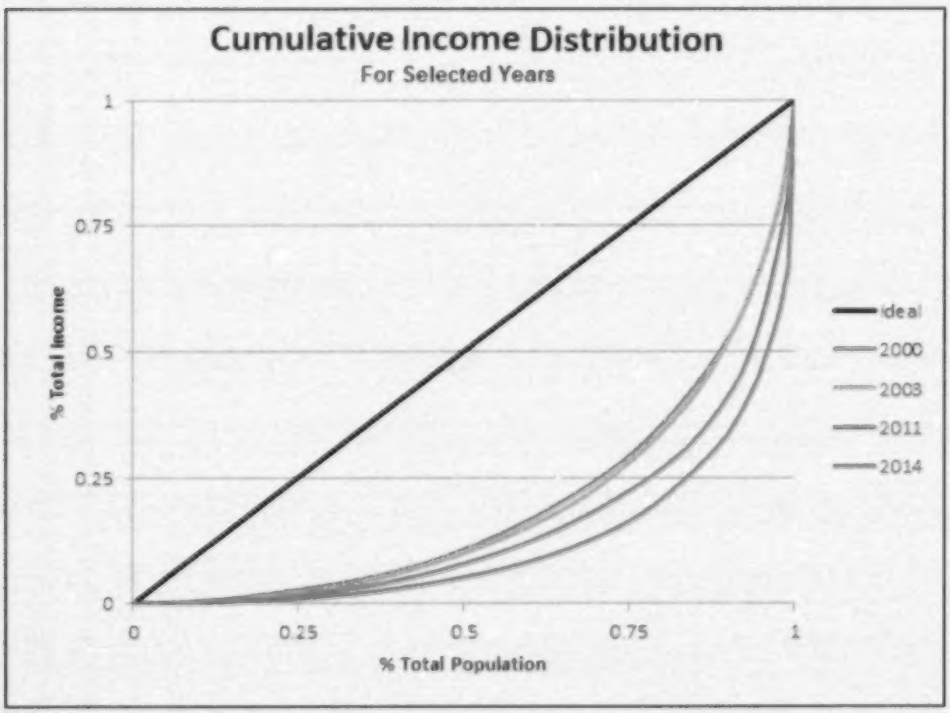

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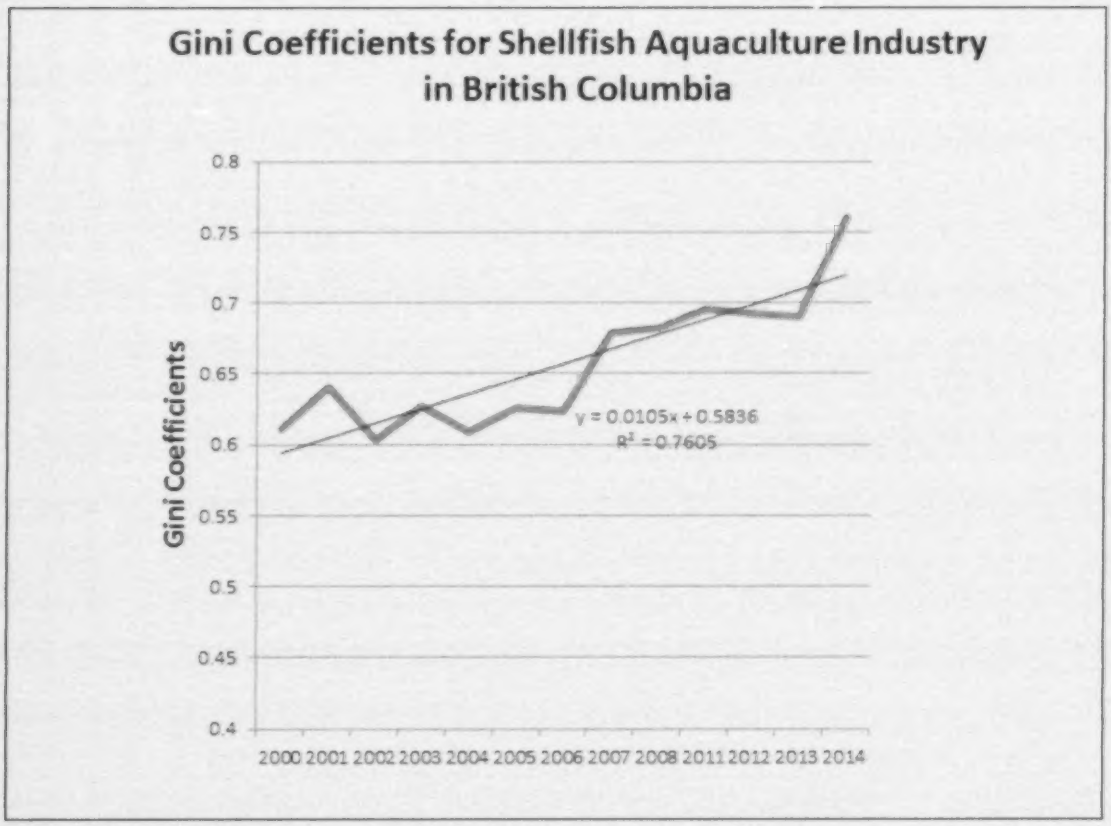

Figure 5

Descriptive Statistics

Year	Max(Y_{tot})	Min(Y_{tot})	Mean(Y_{tot})	Median(Y_{tot})	n	Y_{tot}	Gini
2014	4038530	190	113475	29380	224	25191398	0.761
2013	3046002	130	94218	37284	232	21858492	0.690
2012	1984169	400	75295	26599	251	18899042	0.692
2011	2129419	268	88020	33990	207	18220056	0.695
2008	904746	475	53733	18665	301	16173693	0.682
2007	1117080	468	68196	25000	313	21345370	0.679
2006	753474	433	62258	27755	297	18490555	0.623
2005	537799	178	53300	24329	336	17908671	0.625
2004	499125	225	48894	24400	331	16183883	0.608
2003	609678	300	52350	24400	343	17956005	0.626
2002	694598	162	49774	24558	313	15579237	0.603
2001	900846	150	54044	22212	325	17564390	0.640
2000	484006	60	44838	23292	272	12195987	0.611

Table 1